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(54) **MULTI-LAYER FORMING FABRIC WITH STITCHING YARN PAIRS INTEGRATED INTO PAPERMAKING SURFACE**

MEHRSCICHTIGES FORMIERGEBWEBE MIT IM PAPIERSEITE INTEGRIERTEN NÄHFADENPAAREN

TOILE DE FORMATION MULTICOUCHE POSSEDANT DES PAIRES DE FILS DE PIQUAGE INTEGRES A LA FACE SUR LAQUELLE S'EFFECTUE LA FABRICATION DE PAPIER

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Description**Field of the Invention**

[0001] The present invention relates generally to papermaking, and relates more specifically to fabrics employed in papermaking.

Background of the Invention

[0002] In the conventional fourdrinier papermaking process, a water slurry, or suspension, of cellulosic fibers (known as the paper "stock") is fed onto the top of the upper run of an endless belt of woven wire and/or synthetic material that travels between two or more rolls. The belt, often referred to as a "forming fabric," provides a papermaking surface on the upper surface of its upper run which operates as a filter to separate the cellulosic fibers of the paper stock from the aqueous medium, thereby forming a wet paper web. The aqueous medium drains through mesh openings of the forming fabric, known as drainage holes, by gravity or vacuum located on the lower surface of the upper run (i.e., the "machine side") of the fabric.

[0003] After leaving the forming section, the paper web is transferred to a press section of the paper machine, where it is passed through the nips of one or more pairs of pressure rollers covered with another fabric, typically referred to as a "press felt." Pressure from the rollers removes additional moisture from the web; the moisture removal is often enhanced by the presence of a "batt" layer of the press felt. The paper is then transferred to a drier section for further moisture removal. After drying, the paper is ready for secondary processing and packaging.

[0004] Typically, papermaker's fabrics are manufactured as endless belts by one of two basic weaving techniques. In the first of these techniques, fabrics are flat woven by a flat weaving process, with their ends being joined to form an endless belt by any one of a number of well-known joining methods, such as dismantling and reweaving the ends together (commonly known as splicing), or sewing on a pin-seamable flap or a special fold-back on each end, then reweaving these into pin-seamable loops. In a flat woven papermaker's fabric, the warp yarns extend in the machine direction and the filling yarns extend in the cross machine direction. In the second technique, fabrics are woven directly in the form of a continuous belt with an endless weaving process. In the endless weaving process, the warp yarns extend in the cross machine direction and the filling yarns extend in the machine direction. As used herein, the terms "machine direction" (MD) and "cross machine direction" (CMD) refer, respectively, to a direction aligned with the direction of travel of the papermaker's fabric on the papermaking machine, and a direction parallel to the fabric surface and traverse to the direction of travel. Both weaving methods described hereinabove are well

known in the art, and the term "endless belt" as used herein refers to belts made by either method.

[0005] Effective sheet and fiber support and an absence of wire marking are important considerations in papermaking, especially for the forming section of the papermaking machine, where the wet web is initially formed. Wire marking is particularly problematic in the formation of fine paper grades, as it affects a host of paper properties, such as sheet mark, porosity, see through, and pin holing. Wire marking is the result of individual cellulosic fibers being oriented within the paper web such that their ends reside within gaps between the individual threads or yarns of the forming fabric. This problem is generally addressed by providing a permeable fabric structure with a coplanar surface that allows paper fibers to bridge adjacent yarns of the fabric rather than penetrate the gaps between yarns. As used herein, "coplanar" means that the upper extremities of the yarns defining the paper-forming surface are at substantially the same elevation, such that at that level there is presented a substantially "planar" surface. Accordingly, fine paper grades intended for use in quality printing, carbonizing, cigarettes, electrical condensers, and like grades of fine paper have typically heretofore been formed on very finely woven or fine wire mesh forming fabrics.

[0006] Regretably, such finely woven forming fabrics often are delicate and lack dimensional stability in either or both of the machine and cross machine directions (particularly during operation), leading to a short service life for the fabric. In addition, a fine weave may adversely effect drainage properties of the fabric, thus rendering it less suitable as a forming fabric.

[0007] To combat these problems associated with fine weaves, multi-layer forming fabrics have been developed with fine-mesh yarns on the paper forming surface to facilitate paper formation and coarser-mesh yarns on the machine contact side to provide strength and durability. For example, fabrics have been constructed to include one fabric layer having a fine mesh, another fabric layer having a coarser mesh, and stitching yarns that bind the layers together. These fabrics, known as "triple layer" fabrics, are illustrated in U.S. Patent No. 4,501,303 to Osterberg, U.S. Patent No. 5,152,326 to Vohringer, and U.S. Patent No. 5,437,315 to Ward.

[0008] Although these fabrics have performed successfully, they have some shortcomings that relate to the inclusion of the stitching yarns. In a typical triple layer forming fabric, one or more stitching yarns are positioned between some of the CMD yarns of the top and bottom layers and interwoven with the top and bottom MD yarns. In such a construction, portions of the stitching yarns form part of the papermaking surface of the fabric. As a result, the appearance of paper formed with the fabric can be affected (sometimes adversely) by the presence of the stitching yarns.

[0009] In addition, triple layer fabrics have proven to have problems with interlayer wear. As the fabric is used

on a paper machine, the top and bottom layers tend to shift relative to one another, both in the machine direction and the cross machine direction, due to the tension imparted to the fabric by the rolls. This effect is exacerbated on paper machines, such as the so-called "high-wrap" machines, that include multiple rolls, including some which contact the top layer of the fabric. This shifting can cause the fabric to wear and decrease in thickness, which can adversely affect the drainage of the fabric and, accordingly, its performance in papermaking. In many instances, it is this interlayer wear, rather than the wear of the machine side surface of the fabric machine against the paper machine, that determines the longevity of the fabric.

[0010] Further, because the stitching yarns of a triple layer fabric have a different weave pattern than the top CMD yarns (i.e., they interweave with the bottom CMD yarns also, whereas the top CMD yarns do not), there can be differences in tension between the stitching yarns and the top CMD yarns. These differences can induce the fabric to distort out-of-plane, which can in turn reduce the quality of paper produced with the fabric.

[0011] Also, the stitching yarns of a triple layer fabric should be sufficiently strong and durable to bind the top and bottom layers and to resist the wear and abrasion conditions that the bottom layer experiences while in contact with the paper machine, yet should be delicate enough to produce high quality paper. This balance can be quite difficult to strike.

Summary of Invention

[0012] It is an object of the present invention to provide a multi-layer forming fabric construction with little distortion in the top fabric layer.

[0013] It is also an object of the present invention to provide a multi-layer forming fabric construction that produces a high quality paper.

[0014] It is another object of the present invention to provide a multi-layer forming fabric construction that maintains the top and bottom layers in a tightly bound condition.

[0015] It is a further object of the present invention to provide a multi-layer forming fabric that addresses the problem of interlayer wear.

[0016] These and other objects are satisfied by the present invention, which relates to a multi-layer paper-maker's forming fabric with stitching yarns integrated into the papermaking surface. The fabric is formed as a plurality of repeating units. Each of the repeating units comprises: a set of top machine direction yarns; a set of top cross-machine direction yarns interwoven with the set of top machine direction yarns; a set of bottom machine direction yarns; a set of bottom cross-machine direction yarns interwoven with the set of bottom machine direction yarns; and pairs of first and second stitching yarns. The stitching yarn pairs are positioned between pairs of adjacent top cross-machine direction yarns. The

stitching yarns of each pair are interwoven with the top and bottom machine direction yarns such that, as a fiber support portion of the first stitching yarn is interweaving with the top machine direction yarns, a binding portion of the second stitching yarn is positioned below the top machine direction yarns, and such that as a fiber support portion of the second stitching yarn is interweaving with the top machine direction yarns, a binding portion of the first stitching yarn is positioned below the top machine direction yarns. The first and second stitching yarns cross each other as they pass below a transitional top machine direction yarn. Also, each of the binding portions of the first and second stitching yarns passes below one of the bottom machine direction yarns. A pair of first and second stitching yarns is positioned between each pair of adjacent top cross machine direction yarns. The repeat unit includes ten bottom machine direction yarns and 10 bottom cross machine direction yarns. Each of the bottom machine direction yarns passes, in order, above four consecutive bottom cross machine direction yarns, below a bottom cross machine direction yarn to form a first bottom side machine direction knuckle, above four consecutive bottom cross machine direction yarns, and below a bottom cross machine direction yarn to form a second bottom side machine direction knuckle. A stitching yarn forms a bottom side stitching yarn knuckle below said machine direction yarn between the second and third of each of said four consecutive bottom cross machine direction yarns. In this configuration, the stitching yarns are completely integrated into the top, or papermaking, surface of the fabric, and therefore do not adversely impact the papermaking qualities of the fabric. Also, the relatively large number of stitching yarns provides reliable binding of the top and bottom layers of the fabric.

[0017] In an illustrated embodiment of the fabric, the stitching yarns are interwoven with the top MD and CMD yarns so that they form a plain weave papermaking surface. In this embodiment, the integration of the stitching yarns into the papermaking surface of the fabric addresses many of the problems associated with prior art triple layer fabrics, such as distortion of the papermaking surface and inadequate binding of the top and bottom layers.

Brief Description of the Figures

[0018]

Figure 1A is a top view of an embodiment of a 20 harness multi-layer forming fabric of the present invention having a plain weave top surface.

Figure 1B is a plan view of the bottom layer of the fabric of **Figure 1**.

Figures 2A through **2J** are section views of the stitching yarns of the fabric of **Figures 1A** and **1B**.

Detailed Description of the Preferred Embodiment

[0019] The present invention will be described more particularly hereinafter with reference to the accompanying drawings. The invention is not intended to be limited to the illustrated embodiment; rather, this embodiment is intended to fully and completely disclose the invention to those skilled in this art.

[0020] A 20 harness multi-layer forming fabric, generally designated at 20, is illustrated in **Figures 1A** and **1B**, in which a single repeat unit of the fabric is shown. As seen in **Figure 1A**, the repeat unit of the fabric 20 includes a top layer having ten top MD yarns 21-30 and ten top CMD yarns 31-40. These are interwoven such that each top CMD yarn passes over and beneath top MD yarns in an alternating fashion, with each top CMD yarn passing over and under the same top MD yarns. For example, top CMD yarn 31 passes under top MD yarn 21, over top MD yarn 22, under top MD yarn 23, over top MD yarn 24 and so on until it passes over top MD yarn 30. Similarly, top CMD yarn 32 passes under top MD yarn 21, over top MD yarn 22, under top MD yarn 23, over top MD yarn 24 and so on until it passes over top MD yarn 30.

[0021] Referring now to **Figure 1B**, a repeat unit of the bottom layer of the fabric is shown. The repeat unit includes ten bottom MD yarns 41-50 which are interwoven with ten bottom CMD yarns 51-60. The bottom MD yarns 41-50 are interwoven with the bottom CMD yarns 51-60 in a 1x4 twill type pattern, with each bottom CMD yarn passing above one bottom MD yarn, below four bottom MD yarns, above one bottom MD yarn, and below four bottom MD yarns. For example, bottom CMD yarn 51 passes above bottom MD yarn 41, below bottom MD yarns 42-45, above bottom MD yarn 46, and below bottom MD yarns 47 through 50. The other bottom CMD yarns follow a similar "over 1/under 4" weave pattern, but each is offset from its nearest bottom CMD yarn neighbors by two bottom MD yarns.

Consequently, bottom CMD yarn 52 passes below bottom MD yarns 41 and 42, above bottom MD yarn 43, below bottom MD yarn 44 through 47, above bottom MD yarn 48, and below bottom MD yarns 49 and 50. Thus the "knuckle" formed by bottom MD yarn 43 as it passes below bottom CMD yarn 52 is offset from the "knuckle" formed by bottom MD yarn 41 as it passes over bottom CMD yarn 51 by two bottom MD yarns.

[0022] The top layer (formed by the top MD yarns and the top CMD yarns) and the bottom layer (formed by the bottom MD yarns and the bottom CMD yarns) are stitched together with twenty stitching yarns, designated herein as pairs 61a, 61b through 70a, 70b. The stitching yarns are positioned in pairs between adjacent CMD yarns. For example, stitching yarns 61a and 61b are positioned between top CMD yarns 31 and 32 and between bottom CMD yarns 51 and 52. The stitching yarns interweave with the top MD yarns and bottom MD yarns to bind the top and bottom fabric layers together.

[0023] As can be seen in **Figures 2A** through **2J**, corresponding pairs of stitching yarns interweave with the top MD yarns and bottom MD yarns in the following pattern. Each of the stitching yarns of the repeat unit can be subdivided into two portions: a fiber support portion which interweaves with the top MD yarns, and a binding portion which interweaves with a bottom MD yarn. These are separated at "transitional" top MD yarns, below which one stitching yarn of a pair crosses the other stitching yarn of the pair. The stitching yarns of each pair are interwoven relative to one another such that the fiber support portion of one yarn of the pair is positioned above the binding portion of the other yarn of the pair. The fiber support portion of the stitching yarn of each pair designated with an "a" (e.g., 61a, 62a, 63a) interweaves in an alternating fashion with five top MD yarns (alternately passing over three top MD yarns and under two top MD yarns), and the other stitching yarn of the pair (those designated with a "b") passes over two top MD yarns while passing below a top MD yarn positioned between those two MD yarns. In its fiber support portion, each stitching yarn passes over top MD yarns that the top CMD yarns pass beneath, and passes below top MD yarns that each top CMD yarn passes over. In this manner, the stitching yarns and top CMD form a plain weave pattern with the top MD yarns (see **Figure 1A**). In its binding portion, each stitching yarn passes below one bottom MD yarn in the repeat unit such that an "over 4/under 1" pattern is established by the pair of stitching yarns on the bottom surface of the fabric 20 (see **Figure 1B**).

[0024] The weaving pattern of the stitching yarns is exemplified in **Figure 2D**, which illustrates stitching yarns 64a, 64b interweaving with top and bottom MD yarns. In its fiber support portion, stitching yarn 64a passes over top MD yarns 21, 23 and 25, and below top MD yarns 22 and 24. It then passes below transitional top MD yarn 26 and above bottom MD yarn 46. In its binding portion, stitching yarn 64a passes below top MD yarns 27 through 29 while passing above bottom MD yarns 47 and 49 and below bottom MD yarn 48 to stitch the bottom layer of the fabric 20. Stitching yarn 64a then passes between top transitional MD yarn 30 and bottom MD yarn 50. **Figure 2D** also illustrates that stitching yarn 64b is interwoven such that its binding portion is below that of stitching yarn 64a; stitching yarn 64b passes below top MD yarns 21 through 25 while passing above bottom MD yarns 41, 42, 44, 45 and below bottom MD yarn 43. In its fiber support portion, stitching yarn 64b passes above top MD yarn 27, below top MD yarn 28 and above top MD yarn 29. As a result, the fiber support portions of stitching yarns 64a, 64b combine to form the "over 1/under 1" pattern of a plain weave on the top layer, and the binding portions of stitching yarns 64a, 64b combine to form the "over 4/under 1" pattern described above.

[0025] As can be seen in **Figures 2A** through **2C** and **Figures 2E** through **2J** (which depict the interweaving

patterns of the other stitching yarn pairs with the top and bottom MD yarns), the same pattern described herein-above for the stitching yarns **64a**, **64b** relative to each other is followed by the other stitching yarn pairs.

[0026] Referring back to **Figures 1A** and **1B**, pairs of stitching yarns that are positioned adjacent to and on opposite sides of a top or bottom CMD yarn are interwoven with the top or bottom MD yarns such that there is an offset of two MD yarns between such stitching yarn pairs. For example, stitching yarn **61a** passes above top MD yarns **25**, **27** and **29** and below bottom MD yarn **42**. Stitching yarn **62a** passes above top MD yarns **27**, **29** and **21** (with top MD yarn **21** being a continuation of the pattern on the opposite side) and below bottom MD yarn **44**. Thus, stitching yarn **61a** is offset from stitching yarn **62a** by two top and bottom MD yarns. This same two MD yarn offset is followed for the interweaving of the other stitching yarns.

[0027] It can also be seen in **Figures 1A** and **1B** that the stitching yarns are interwoven with the top and bottom MD yarns as "reversed picks." This term can be understood by examination of stitching yarn pairs **61a**, **61b**, **62a**, **62b**, **63a**, **63b**. As shown in **Figures 1A** and **2A**, stitching yarn **61a** is positioned nearer to top CMD yarn **32** than is stitching yarn **61b**. As seen in **Figures 1A** and **2B**, on the other side of top CMD yarn **32**, stitching yarn **62a** is positioned nearer to top CMD yarn **32** than is stitching yarn **62b**. As a result, the fiber support portions of stitching yarns **61a**, **62a** are positioned nearer to top CMD yarn **32** than are the fiber support portions of stitching yarns **61b**, **62b**. This relative proximity to the top CMD yarn between adjacent pairs of stitching yarns is reversed with stitching yarn pairs **62a**, **62b** and **63a**, **63b**. As seen in **Figures 1A**, **2B**, and **2C**, stitching yarns **62b** and **63b** are positioned nearer top CMD yarn **33** than stitching yarns **62a**, **63a**, with the result again that the fiber support portions of the nearer stitching yarns are also positioned nearer to top CMD yarn **33**.

[0028] It has been discovered that this "reversed picks" configuration is particularly effective in masking the presence of stitching yarns in the top surface of the fabric. When a transitional yarn passes over the stitching yarns of a pair to form a top surface knuckle, that knuckle tends to receive less upwardly-directed support from the stitching yarns at that location than other locations on the top MD yarn where it passes over a stitching yarn or top CMD yarn. As a result, that knuckle tends to be positioned slightly lower than the other top MD knuckles. As seen in **Figure 1A**, the top MD knuckles of transitional yarns form a diagonal line; because the knuckles of this diagonal may all be positioned somewhat lower than the remaining top MD knuckles, paper formed on such a fabric can show this pattern, which can in turn affect images printed thereon. By including the stitching yarns as reversed picks, such as is illustrated in fabric **20**, however, the diagonal formed by the transitional top MD knuckles is disturbed somewhat and is less distinctly defined. As such, paper formed on fabric **20** has a

less distinct diagonal pattern due to these knuckles, and printing on the paper is improved.

[0029] Those skilled in this art will appreciate that the afore-described "reverse picks" configuration is created in the fabric by weaving the stitching yarns into the top and bottom MD yarns so that first an "a" stitching yarn immediately follows the weaving of top and bottom CMD yarns (followed by a "b" stitching yarn), then a "b" stitching yarn immediately follows the next set of top and bottom CMD yarns (followed by an "a" stitching yarn). This pattern can be repeated throughout weaving. Although it is preferred that all of the stitching yarn pairs follow this pattern (i.e., that 50 percent of the stitching yarn pairs be "reversed"), some benefit can be obtained by reversing only a smaller percentage (for example 25, 33, or 40 percent) of the stitching yarn pairs.

[0030] Those skilled in this art will recognize that, although the plain weave fabric illustrated and described in detail herein is preferred, other fabric weaves, such as twill weaves and satins, that employ pairs of stitching yarns integrated into the papermaking surface of a fabric with the top CMD yarns can also be made. In addition, although the illustrated fabrics have equal numbers of top and bottom MD and CMD yarns, this need not be the case for the present invention; other ratios, such as two top CMD yarns for each bottom CMD yarn, can also be employed.

[0031] The configurations of the individual yarns utilized in the fabrics of the present invention can vary, depending upon the desired properties of the final papermakers' fabric. For example, the yarns may be multifilament yarns, monofilament yarns, twisted multifilament or monofilament yarns, spun yarns, or any combination thereof. Also, the materials comprising yarns employed in the fabric of the present invention may be those commonly used in papermakers' fabric. For example, the yarns may be formed of cotton, wool, polypropylene, polyester, aramid, nylon, or the like. The skilled artisan should select a yarn material according to the particular application of the final fabric.

[0032] Regarding yarn dimensions, the particular size of the yarns is typically governed by the size and spacing of the papermaking surface. Generally, the diameter of the top CMD yarns is about 25 to 75 percent of the diameter of the bottom CMD yarns, and the diameter of the top MD yarns is about equal to or smaller than the diameter of the top CMD yarns. In a typical fabric, the diameter of the top CMD yarns is between about 0.11 and 0.17mm, the diameter of the top MD yarns is between about 0.11 and 0.15mm, the diameter of the bottom CMD yarns is between about 0.20 and 0.40mm, and the diameter of the bottom MD yarns is between about 0.17 and 0.25mm. The diameter of the stitching yarns is typically between about 0.11 and 0.17mm.

[0033] Yarns may also vary advantageously in modulus of elasticity. For example, stitching yarns that interweave with a fewer number of top MD yarns than its paired stitching yarn (such as the "b" yarns of fabric **20**)

may have a higher modulus of elasticity (typically between about 10 and 50 percent higher) than its paired stitching yarn.

[0034] As the foregoing discussion demonstrates, the fabrics of the present invention address problems encountered with prior art triple layer forming fabrics. The fabrics of the present invention integrate the stitching yarns into the top surface of the fabric, whether it be a plain weave, a twill, a satin, or other pattern, and therefore avoid the marring of the papermaking surface that can accompany stitching yarns that comprise less of the papermaking surface. The integration of the fabric attributable to the stitching yarns also greatly reduces (if not eliminating) interlayer wear. In addition, because the stitching yarns comprise such a large portion of the papermaking surface, the differences in tension between the top CMD yarns and the stitching yarns that can distort the papermaking surfaces of other fabric are less critical to the fabrics of the present invention. The density of the stitching yarns also provides a tighter and more reliable binding of the top and bottom layers of the fabric, which can provide the designer with a wider variety of yarn choices to balance paper forming properties, durability and wear.

Claims

1. A papermaker's fabric (20), comprising top machine direction yarns (21-30), top cross machine direction yarns (31-40), bottom machine direction yarns (41-50), bottom cross machine direction yarns (51-60), and sets of first and second stitching yarns (61a-70a and 61 b-70b), said fabric being formed in a plurality of repeating units, each of said repeating units comprising:

a set of top machine direction yarns;

a set of top cross machine direction yarns interwoven with said set of top machine direction yarns;

a set of bottom machine direction yarns;

a set of bottom cross machine direction yarns interwoven with said set of bottom machine direction yarns;

wherein pairs of first and second stitching yarns are positioned between pairs of adjacent top cross machine direction yarns, said first and second stitching yarns of each pair being interwoven with said top and bottom machine direction yarns such that as a fiber support portion of said first stitching yarn is interweaving with said top machine direction yarns, a binding portion of said second stitching yarn is positioned below said top machine direction yarns,

and such that as a fiber support portion of said second stitching yarn is interweaving with said top machine direction yarns, a binding portion of said first stitching yarn is positioned below said top machine direction yarns, and such that said first and second stitching yarns cross each other as they pass below a transitional top machine direction yarn, and such that each of said binding portions of said first and second stitching yarns passes below one of said bottom machine direction yarns;

characterized in that

a pair of first and second stitching yarns is positioned between each pair of adjacent top cross machine direction yarns;

that said repeat unit of said fabric includes 10 bottom machine direction yarns and 10 bottom cross machine direction yarns; and

that each of said bottom machine direction yarns passes, in order, above four consecutive bottom cross machine direction yarns, below a bottom cross machine direction yarn to form a first bottom side machine direction knuckle, above four consecutive bottom cross machine direction yarns, and below a bottom cross machine direction yarn to form a second bottom side machine direction knuckle, and wherein a stitching yarn forms a bottom side stitching yarn knuckle below said machine direction yarn between the second and third of each of said four consecutive bottom cross machine direction yarns.

2. The papermaker's fabric defined in Claim 1, wherein each bottom side machine direction knuckle formed by a bottom machine direction yarn is offset from adjacent bottom side machine direction knuckles formed by an adjacent bottom machine direction yarn by three bottom cross machine direction yarns, in one direction parallel to the machine direction and by two bottom cross machine direction yarns in the opposite direction parallel to the machine direction.
3. The papermaker's fabric defined in claim 1 or 2, wherein each of said first stitching yarns of each pair passes over a first number of top machine direction yarns, and each of said second stitching yarns of each pair passes over a second number of top machine direction yarns; wherein said first number is different from said second number and wherein at least some of the top cross machine direction yarns are immediately adjacent to either two first stitching yarns or two second stitching yarns.
4. The papermaker's fabric defined in claim 3, wherein each of the top cross machine direction yarns positioned between adjacent pairs of stitching yarns is immediately adjacent to either two first stitching yarns or two second stitching yarns.

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5. A method of making paper, said method comprising the steps of:

- (a) providing a papermaker's fabric according to one or more of the claims 1 to 4,
- (b) applying paper stock to said papermaker's fabric, and
- (c) removing moisture from said paper stock.

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Patentansprüche

1. Papiermaschinensieb (20), das aufweist: obere Maschinenrichtungsfäden (21 bis 30), obere Maschinenquerrichtungsfäden (31 bis 40), untere Maschinenrichtungsfäden (41 bis 50), untere Maschinenquerrichtungsfäden (51 bis 60) und Sätze von ersten und zweiten Heftfäden (61a bis 70a und 61b bis 70b), wobei das Sieb in einer Vielzahl von sich wiederholenden Einheiten gebildet ist, wobei jede der sich wiederholenden Einheiten aufweist:

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einen Satz von oberen Maschinenrichtungsfäden;

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einen Satz von oberen Maschinenquerrichtungsfäden, die mit dem Satz von oberen Maschinenrichtungsfäden verwebt sind;

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einen Satz von unteren Maschinenrichtungsfäden;

einen Satz von unteren Maschinenquerrichtungsfäden, die mit dem Satz von unteren Maschinenrichtungsfäden verwebt sind,

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wobei Paare von ersten und zweiten Heftfäden zwischen Paaren von benachbarten oberen Maschinenquerrichtungsfäden positioniert sind, wobei die ersten und zweiten Heftfäden jedes Paares mit den oberen und unteren Maschinenrichtungsfäden verwebt sind, so daß, während ein Faserstützbereich des ersten Heftfadens mit den oberen Maschinenrichtungsfäden verwebt wird, ein Bindungsbereich des zweiten Heftfadens unter den oberen Maschinenrichtungsfäden positioniert wird, und so daß, während ein Faserstützbereich des zweiten Heftfadens mit den oberen Maschinenrichtungsfäden verwebt wird, ein Bindungsbereich des ersten Heftfadens unter den oberen Maschinenrichtungsfäden positioniert wird, und so daß die ersten und zweiten Heftfäden einander kreuzen, während sie unter einem oberen Maschinenrichtungs-Übergangsfaden durchlaufen, und so daß jeder der Bindungsbereiche der ersten und zweiten Heftfäden unter einem der unteren Maschinenrichtungsfäden durchläuft;

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dadurch gekennzeichnet, daß

ein Paar von ersten und zweiten Heftfäden zwischen jedem Paar von benachbarten oberen Maschinenquerrichtungsfäden positioniert ist; daß die sich wiederholende Einheit des Siebs 10 untere Maschinenrichtungsfäden und 10 untere Maschinenquerrichtungsfäden aufweist; und daß jeder der unteren Maschinenrichtungsfäden in der angegebenen Reihenfolge wie folgt verläuft: über vier konsekutive untere Maschinenquerrichtungsfäden, unter einem unteren Maschinenrichtungsfaden, um einen ersten unterseitigen Maschinenrichtungshöcker zu bilden, über vier konsekutive untere Maschinenquerrichtungsfäden und unter einem unteren Maschinenquerrichtungsfaden, um einen zweiten unterseitigen Maschinenrichtungshöcker zu bilden, und wobei ein Heftfaden einen unterseitigen Heftfadenhöcker unter dem Maschinenrichtungsfaden zwischen dem zweiten und dritten von jedem der vier konsekutiven unteren Maschinenquerrichtungsfäden bildet.

2. Papiermaschinensieb nach Anspruch 1, wobei jeder unterseitige Maschinenrichtungshöcker, der von einem unteren Maschinenrichtungsfaden gebildet ist, von benachbarten unterseitigen Maschinenrichtungshöckern, die von einem benachbarten unteren Maschinenrichtungsfaden gebildet sind, in einer Richtung parallel zu der Maschinenrichtung um drei untere Maschinenquerrichtungsfäden und in der entgegengesetzten Richtung parallel zu der Maschinenrichtung um zwei untere Maschinenquerrichtungsfäden versetzt ist.

3. Papiermaschinensieb nach Anspruch 1 oder 2, wobei jeder der ersten Heftfäden jedes Paares über eine erste Anzahl von oberen Maschinenrichtungsfäden läuft und jeder der zweiten Heftfäden jedes Paares über eine zweite Anzahl von oberen Maschinenrichtungsfäden läuft;

wobei die erste Anzahl von der zweiten Anzahl verschieden ist und wobei mindestens einige der oberen Maschinenquerrichtungsfäden entweder zwei ersten Heftfäden oder zwei zweiten Heftfäden unmittelbar benachbart sind.

4. Papiermaschinensieb nach Anspruch 3, wobei jeder der oberen Maschinenquerrichtungsfäden, die zwischen benachbarten Paaren von Heftfäden positioniert sind, entweder zwei ersten Heftfäden oder zwei zweiten Heftfäden unmittelbar benachbart ist.

5. Verfahren zum Herstellen von Papier, wobei das Verfahren die folgenden Schritte aufweist:

- (a) Vorsehen eines Papiermaschinensiebs nach einem oder mehreren der Ansprüche 1 bis 4,

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(b) Aufbringen von Papierbrei auf das Papiermaschinensieb, und

(c) Entfernen von Feuchtigkeit aus dem Papierbrei.

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Revendications

1. Toile (20) de machine à papier, comprenant des fils supérieurs dans le sens de fabrication (21-30), des fils supérieurs dans le sens travers (31-40), des fils inférieurs dans le sens de fabrication (41-50), des fils inférieurs dans le sens travers (51-60), et un ensemble de premier et deuxième fils de couture (61a-70a et 61b-70b), ladite toile étant formée par une pluralité d'unités qui se répètent, chacune desdites unités qui se répète comprenant :

un ensemble de fils supérieurs dans le sens de fabrication ;

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un ensemble de fils supérieurs dans le sens travers entrelacés avec ledit ensemble de fils supérieurs dans le sens de fabrication ;

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un ensemble de fils inférieurs dans le sens de fabrication ;

un ensemble de fils inférieurs dans le sens travers entrelacés avec ledit ensemble de fils inférieurs dans le sens de fabrication ;

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dans laquelle des paires de premier et deuxième fils de couture sont positionnés entre des paires de fils supérieurs adjacents dans le sens travers, lesdits premier et deuxième fils de couture de chaque paire étant entrelacés avec lesdits fils supérieurs et inférieurs dans le sens de fabrication, de sorte qu'une partie formant support de fibres dudit premier fil de couture s'entrelace avec lesdits fils supérieurs dans le sens de fabrication, une partie de liaison dudit deuxième fil de couture est positionné sous lesdits fils supérieurs dans le sens de fabrication, et de sorte qu'une partie formant support de fibres dudit deuxième fil de couture s'entrelace avec lesdits fils supérieurs dans le sens de fabrication, une partie de liaison dudit premier fil de couture est positionnée sous lesdits fils supérieurs dans le sens de fabrication, et lesdits premier et deuxième fils de couture se croisent entre eux alors qu'ils passent sous un fil supérieur de transition dans le sens de fabrication, et de sorte que chacune desdites parties de liaison desdits premier et deuxième fils de couture passe sous un desdits fils inférieurs dans le sens de fabrication ;

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caractérisée en ce que

une paire d'un premier et deuxième fils de couture

est positionnée entre chaque paire de fils supérieurs adjacents dans le sens travers ; et **en ce que** ladite unité répétitive de ladite toile comprend 10 fils inférieurs dans le sens de fabrication et 10 fils inférieurs dans le sens travers ; et chacun desdits fils inférieurs dans le sens de fabrication passe, dans l'ordre, sur quatre fils inférieurs consécutifs dans le sens travers, sous un fil inférieur dans le sens travers, pour former un premier croisement du côté inférieur dans le sens de fabrication, sur quatre fils inférieurs consécutifs dans le sens travers, et sous un fil inférieur dans le sens travers, pour former un deuxième croisement du côté inférieur dans le sens de fabrication, et dans laquelle un fil de couture forme un croisement de fil de couture du côté inférieur sous ledit fil dans le sens de fabrication entre le deuxième et le troisième de chacun desdits quatre fils inférieurs consécutifs dans le sens travers.

2. Toile de machine à papier selon la revendication 1, dans laquelle chacun des croisements du côté inférieur dans le sens de fabrication, formé par un fil inférieur dans le sens de fabrication est décalé par rapport au croisement du côté inférieur adjacent dans le sens de fabrication formé par un fil inférieur adjacent dans le sens de fabrication, de trois fils inférieurs dans le sens travers, dans une direction parallèle au sens de fabrication et de deux fils inférieurs dans le sens travers dans la direction opposée, parallèle au sens de fabrication.
3. Toile de machine à papier selon la revendication 1 ou 2, dans laquelle chacun desdits premiers fils de couture de chaque paire passe sur un premier nombre de fils supérieurs dans le sens de fabrication, et chacun desdits deuxièmes fils de couture de chaque paire passe sur un deuxième nombre de fils supérieurs dans le sens de fabrication ; dans laquelle ledit premier nombre diffère dudit deuxième nombre et dans laquelle au moins quelques uns des fils supérieurs dans le sens travers sont immédiatement adjacents à l'un ou l'autre des deux premiers fils de couture ou des deux deuxièmes fils de couture.
4. Toile de machine à papier selon la revendication 3, dans laquelle chacun des fils supérieurs dans le sens travers, positionné entre des paires adjacentes de fils de couture est immédiatement adjacent à l'un ou l'autre des deux premiers fils de couture ou des deux deuxièmes fils de couture.
5. Procédé de fabrication du papier, ledit procédé comprenant les étapes suivantes :

(a) fournir une toile de machine à papier selon l'une ou plusieurs des revendications 1 à 4,

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(b) appliquer la pâte à papier sur ladite toile de machine à papier,

(c) éliminer l'humidité de ladite pâte à papier.

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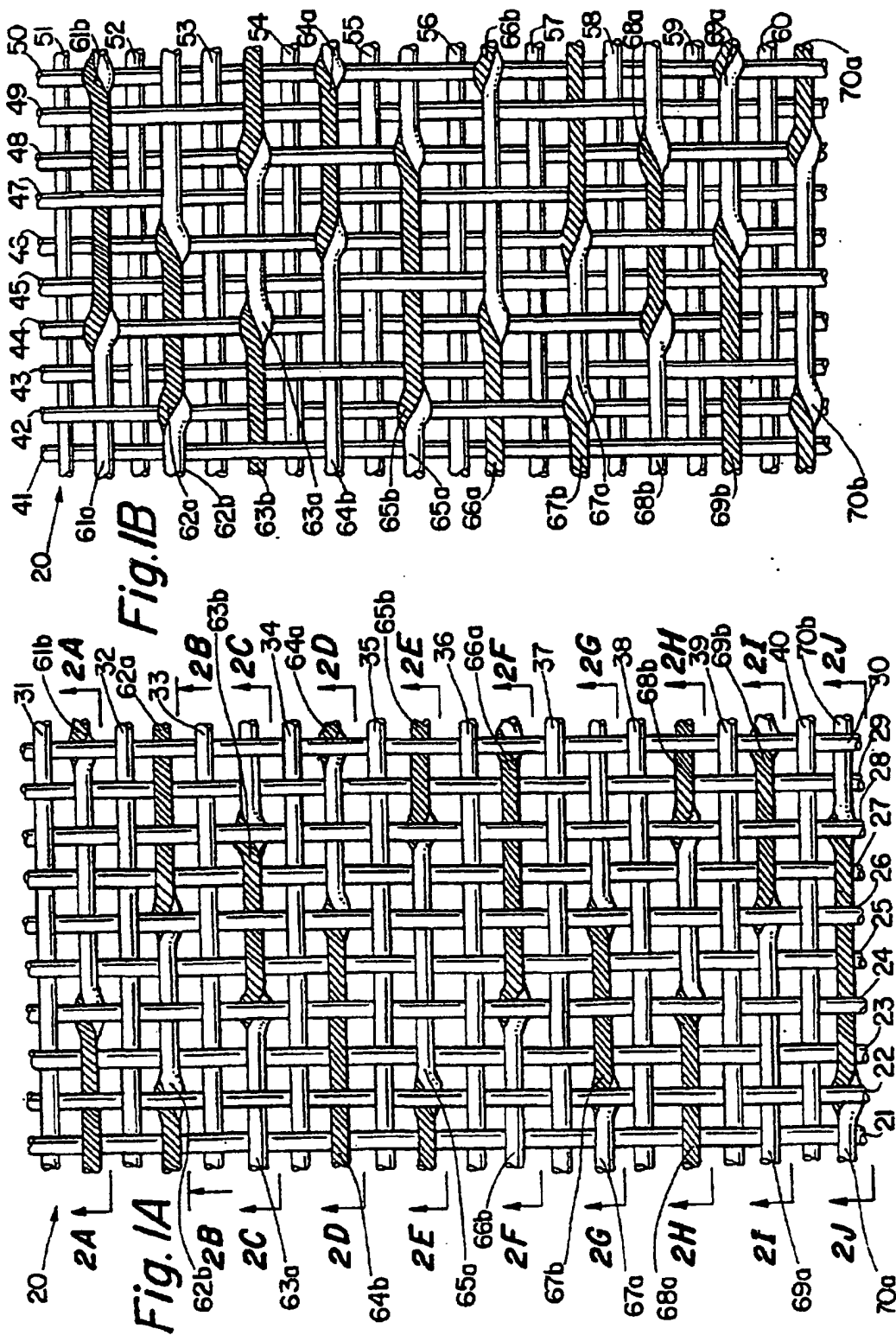
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